



EDGEWOOD

CHEMICAL BIOLOGICAL CENTER

U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-005

DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING OF CHEMPRUF II BETEX SUIT

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Aberdeen Proving Ground, MD 21010-5424

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Preface

The work described in this report was authorized under the Expert Assistance (Personal Protective Equipment Evaluation) Program for the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)* Program Director for Domestic Preparedness. This work was started in February 1998 and completed in March 1998.

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* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

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**DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING
OF CHEMPRUF II BETEX SUIT**

1. INTRODUCTION

Under the Domestic Preparedness (DP) Expert Assistance (Personal Protective Equipment (PPE) Evaluation) Program, the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)* was tasked to perform testing of swatches taken from commercially-available Level A suits currently being used by emergency responders from cities involved in this program. The testing was performed by the Design Evaluation Group, Surety Team, Methodology, Instrumentation and Test Office, Engineering Directorate. The test procedure was jointly developed and agreed upon by ERDEC and the U. S. Army Natick, Research, Development and Engineering Center (NRDEC) (written communication, M. Chin, NRDEC, 1 May 97).

2. MATERIALS AND METHODS

2.1 Suit Description.

The Chempruf II Betex suit was manufactured by Mine Safety Appliances Company, (Pittsburgh, PA) and was orange in color. There was no model number but it was identified as part number FP100. Figure 1 is a digital photograph of the label found inside the suit.

2.2 Swatch Preparation.

The day before testing was scheduled to begin, the suit was picked up from Mask Issue and transported to the laboratory. The suit was folded up for transport and was hung on a hanger once in the laboratory. The suit was stored this way during and after testing.

The swatch locations to be sampled were given in the PPE Test Team Work Contract for Level A Ensembles (written communication, R. Belmonte, Engineering Directorate, ERDEC, 25 June 1997). These swatch sampling locations were listed as suit material (SM), suit seam (SS), visor material (VM), zipper/suit material seam (ZP), glove (GL), and visor material/suit material seam (SV). The suit pass through could not be sampled because it could not be made flat to fit in a permeation cell. The swatches were normally cut the day before testing and conditioned overnight at the test conditions. For a Monday test, swatches were cut Friday and conditioned over the weekend. Normally, the swatches would be laid in the environmental cabinet for conditioning.

* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

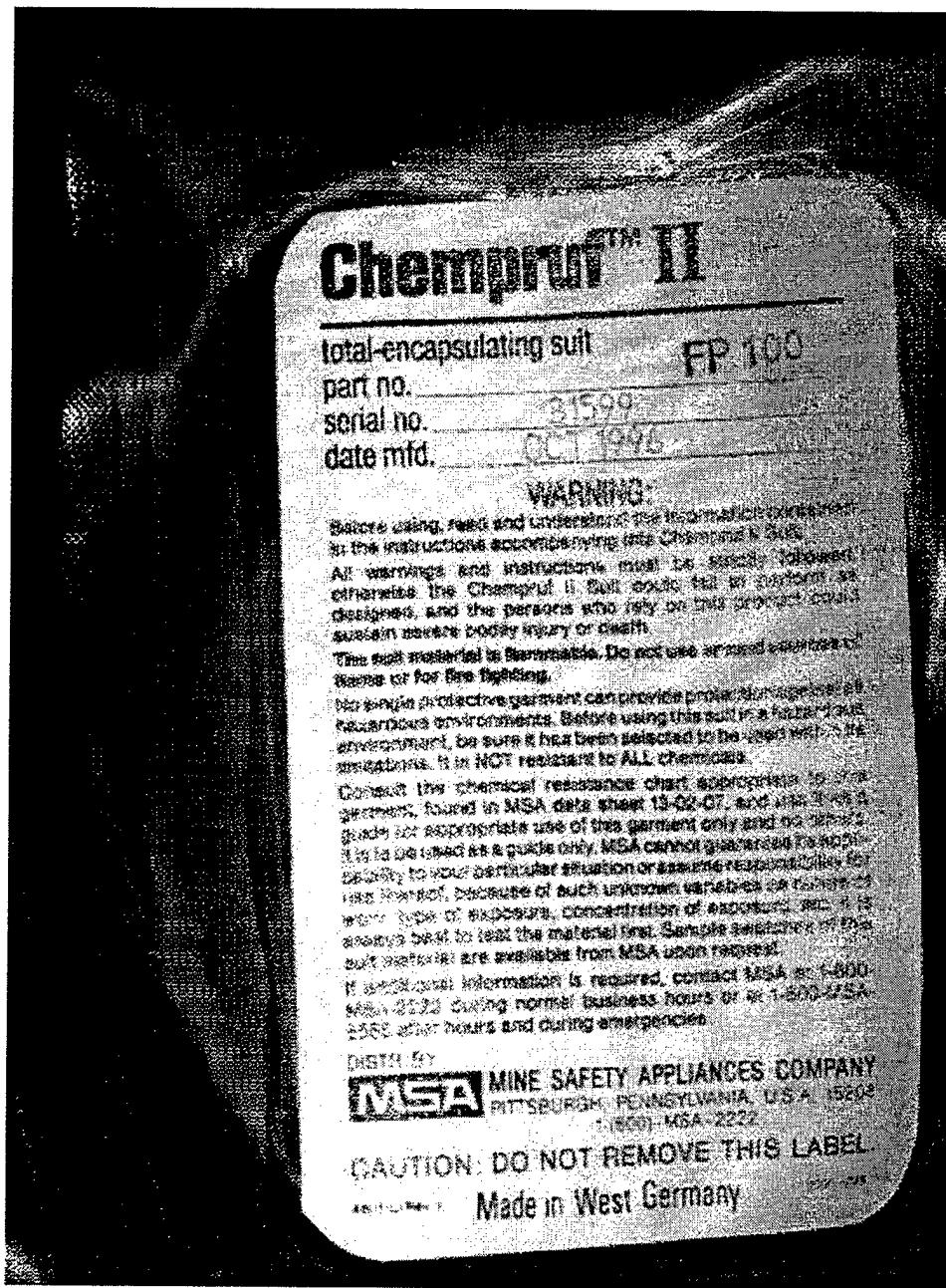


Figure 1. Chempruf II Label

The swatches were numbered in accordance with the PPE Test Team Work Instructions (written communication, R. Belmonte, Engineering Directorate, ERDEC, 11 June 1997); for example LC-MSA-SM-01, etc. All swatches were cut in triplicate, one at a time on a sample press. The swatch diameter was 2 in.

The reference material was 80-mil silicone, using the M45 mask formulation, prepared by Malcolm Little of the M45 mask team. Preparation and conditioning were the same as for the suit swatches.

2.3

Test Procedure.

The procedure agreed upon by ERDEC and NRDEC was derived from the report entitled, "Permeation and Penetration Testing of Air Permeable, Semi-permeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing)" dated 3 March 1997. The Modified Static Diffusion Procedure is found in Appendix A of this report. Subsequent to the agreement, ERDEC personnel determined that the usage of the 80-mil silicone did not meet the definition of a positive control. The silicone swatches were used as an indication of agent vapor permeation. Equipment and schedule limitations prevented the use of negative controls. The terminology of the test procedure was not modified to reflect these changes.

The TOP permeation cell was used and a digital photograph of one is given as Figure 2.

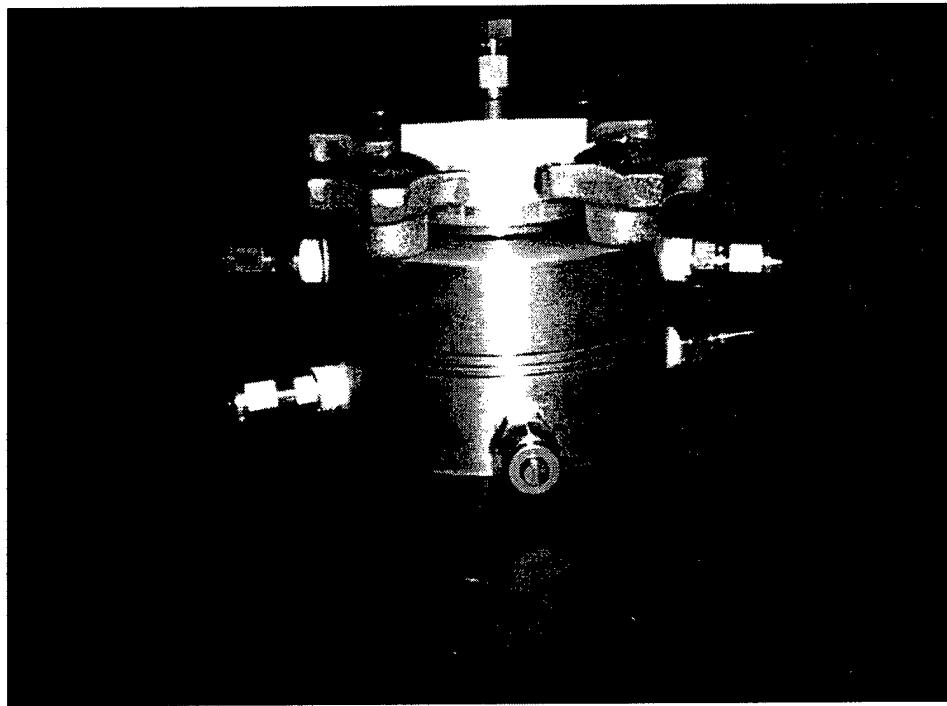


Figure 2. TOP Permeation Cell

The remainder of the test apparatus consisted of the following.

- Plastic environmental cabinet with sliding doors containing a permeation cell rack, circulating blower, and heat source (Figure 3).
- Flow/temperature/relative humidity control system; (Miller-Nelson Research Corporation, Monterey, CA) model HCS-410.

- Flow control system; (Tylan General Incorporated, Torrance, CA) Dynamass model FM-8.
- Mass flow controllers; (Tylan General Incorporated, Torrance, CA) model FC-260.
- Calibrated Vaisala humidity and temperature indicator.
- MINICAMS, serial number 2362, and Stream Selection System (CMS Research Corporation, Birmingham, AL), illustrated in Figure 4.

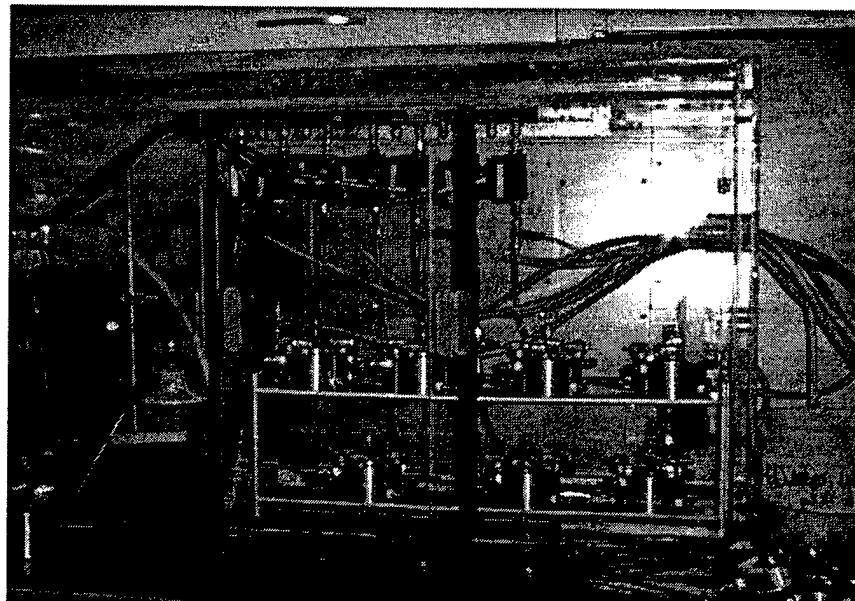


Figure 3. Environmental Cabinet

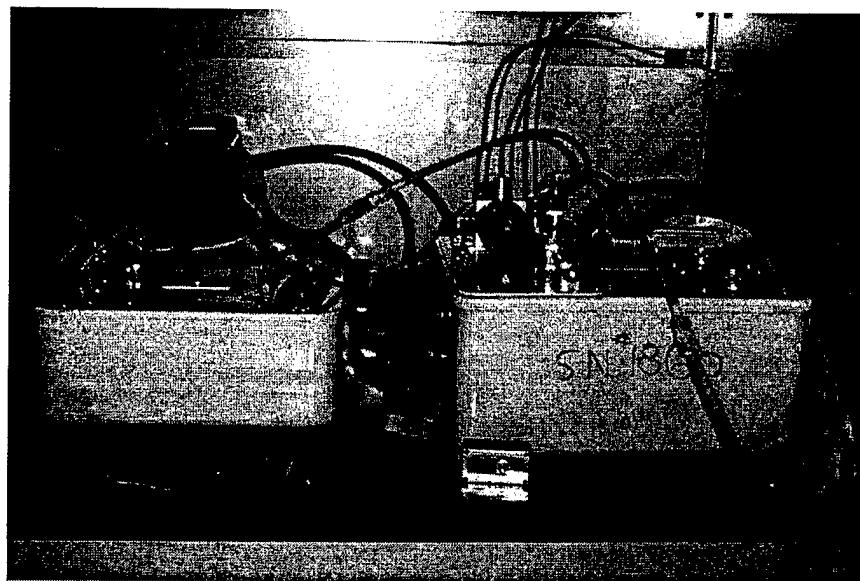


Figure 4. MINICAMS and Stream Selection System

3. RESULTS AND DISCUSSION

3.1 HD Results.

The HD permeation results are given in Appendix B as Tables B-1 through B-6. Average elapsed time was not used. The actual time that each swatch was sampled by the MINICAMS is shown.

The MINICAMS minimum detection limit was 1.0 ng for all test days. There were no visible effects on any of the materials from HD exposure. Cumulative permeation was lowest for the glove material. Cumulative permeation was similar for all other swatches, including the suit material.

The average temperature was 90.3 °F, and 47.8% RH was the average for all tests. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

3.2 GB Results.

The GB permeation results are given in Appendix C as Tables C-1 through C-6.

The MINICAMS minimum detection limit was 0.4 ng for all test days. There were no visible effects on any of the materials from GB exposure. Cumulative permeation was highest for the zipper/material interface (several times higher than for the suit material). Most other swatches had cumulative permeation that was similar to the suit material.

The average temperature was 91.7 °F and 39.2% RH was the average for all tests. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

3.3 Material Thickness.

After the HD and GB testing was completed, thickness measurements of the suit material, visor material, and glove material were made. A swatch of material was cut from the suit immediately adjacent to the area from which the agent swatches were taken. Twenty-four thickness measurements were taken on each swatch using an Ames dial comparator (B. C. Ames Company, Waltham, MA). The average thickness of the suit material swatch was 0.020 in., the outer visor material swatch was 0.010 in., and the glove swatch was 0.026 in.

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APPENDIX A
MODIFIED STATIC DIFFUSION PROCEDURE

MODIFIED STATIC DIFFUSION TEST

This test procedure was adapted from the "Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; delta p = 0, Single Flow Test) given in Test Operations Procedure (TOP) 8-2-501 dated 3 Mar 97.

The following procedure will be used:

Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.

From each suit, 3 ea 1 and 15/16 in. diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, three seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as other seams, visor, gloves, booties, etc. for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number which will be placed on the bag. A list of serial numbers will be kept with the swatches.

The environmental chamber will be controlled at a temperature of 90 +/- 2 °F, and the maximum achievable RH without occurrence of condensation (70% +/- 10% RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. There will be no system control and data acquisition system. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. There will be no differential pressure monitoring since differential pressure gages of sufficient sensitivity are not available.

The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller (cell lugs will be retightened if flows don't match).

The samples will serve as their own negative controls while being preconditioned overnight by being MINICAMS monitored. Eighty mil silicone will be used as a positive control for each test (six suit swatches and one silicone swatch).

Agents GB and HD will be used. The contamination density will be 10 g/m² (eight each 1 µl HD droplets or ten each 1 µl GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.

Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-min cycle. There will be three blank sampling intervals following the control. Each swatch will be sampled once every 30 min. The MINICAMS will be standardized weekly.

The test length will be 24 hr.

The test cells and o-rings will be aerated between uses. No other cleaning method will be used.

The data to be reported are cumulative penetration (ng/cm²) versus average elapsed time (minutes) for each swatch. The average elapsed time is the sum of the elapsed time for swatch 1 and the elapsed time for swatch 6 divided by 2. All recorded data will be placed in laboratory notebooks and a technical report will be drafted at the conclusion of this effort.

For entry into the DP database, the data for each swatch will be reported as cumulative penetration for the first four sampling intervals (approximately 12, 42, 72, and 102 min), and at approximately 6, 12, 18, and 24 hr.

Appendix A

APPENDIX B

HD TABLES

Table B-1. Chempruf II Suit Material vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 17 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
2	1	5	2	8	2
33	21	36	12	39	11
63	27	66	16	69	14
93	33	96	21	99	14
123	40	126	26	129	17
153	49	156	34	159	24
183	62	186	45	189	32
214	83	217	63	220	47
244	118	247	96	250	78
274	175	277	154	280	135
304	258	307	243	310	225
334	373	337	366	340	355
364	527	367	533	370	534
395	730	398	758	401	780
425	998	428	1067	431	1121
455	1351	458	1493	461	1586
485	1804	488	2048	491	2182
515	2365	518	2692	521	2859
545	3001	548	3377	551	3560
576	3662	579	4068	582	4270
606	4340	609	4766	612	4978
636	5030	639	5471	642	5691
666	5727	669	6179	672	6410
696	6431	699	6892	702	7135
726	7130	729	7604	732	7865
757	7832	760	8315	763	8586
787	8537	790	9025	793	9307
817	9242	820	9729	823	10028
847	9951	850	10438	853	10754
877	10657	880	11154	883	11486
907	11367	910	11862	913	12211
938	12083	941	12576	944	12945
968	12794	971	13298	974	13686
998	13518	1001	14033	1004	14440
1028	14253	1031	14783	1034	15206
1058	14987	1061	15529	1064	15967
1088	15717	1091	16269	1094	16724
1119	16444	1122	17006	1125	17467
1149	17167	1152	17741	1155	18209
1179	17885	1182	18473	1185	18960
1209	18609	1212	19210	1215	19714
1239	19335	1242	19950	1245	20473
1269	20073	1272	20702	1275	21247
1300	20816	1303	21461	1306	22027
1330	21546	1333	22209	1336	22800
1360	22272	1363	22954	1366	23566
1390	23000	1393	23699	1396	24327
1420	23746	1423	24462	1426	25110

Table B-2. Chempruf II Suit Seam vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 17 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
11	2	14	2	17	3
42	11	45	10	48	11
72	18	75	16	78	14
102	25	105	18	108	14
132	32	135	20	138	16
162	41	165	25	168	21
192	52	195	31	198	27
223	65	226	39	229	33
253	81	256	49	259	42
283	102	286	61	289	52
313	130	316	78	319	68
343	169	346	105	349	93
373	219	376	144	379	129
404	282	407	196	410	179
434	358	437	263	440	244
464	449	467	344	470	321
494	554	497	441	500	414
524	676	527	550	530	523
554	812	557	675	560	648
585	964	588	815	591	786
615	1132	618	969	621	938
645	1317	648	1139	651	1105
675	1519	678	1325	681	1285
705	1740	708	1524	711	1481
735	1978	738	1738	741	1692
766	2229	769	1970	772	1917
796	2492	799	2218	802	2152
826	2769	829	2480	832	2396
856	3064	859	2750	862	2650
886	3378	889	3036	892	2915
916	3703	919	3337	922	3188
947	4037	950	3646	953	3472
977	4381	980	3964	983	3767
1007	4737	1010	4291	1013	4063
1037	5105	1040	4625	1043	4363
1067	5484	1070	4964	1073	4672
1097	5875	1100	5312	1103	4988
1128	6269	1131	5663	1134	5308
1158	6665	1161	6015	1164	5633
1188	7070	1191	6369	1194	5961
1218	7482	1221	6722	1224	6291
1248	7893	1251	7078	1254	6619
1278	8303	1281	7432	1284	6952
1309	8713	1312	7784	1315	7288
1339	9119	1342	8132	1345	7619
1369	9528	1372	8479	1375	7949
1399	9938	1402	8826	1405	8280
1429	10344	1432	9167	1435	8606

Appendix B

Table B-3. Chempruf II Glove Material vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 19 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
3	1	6	1	9	2
33	24	36	10	39	16
63	46	66	18	69	30
93	70	96	29	99	46
124	100	127	42	130	63
154	135	157	57	160	84
184	176	187	75	190	107
214	222	217	97	220	133
244	271	247	123	250	162
274	325	277	154	280	194
305	382	308	188	311	230
335	443	338	224	341	267
365	506	368	263	371	306
395	570	398	305	401	346
425	634	428	349	431	388
455	700	458	394	461	431
486	767	489	441	492	475
516	835	519	488	522	521
546	903	549	536	552	566
576	972	579	584	582	611
606	1042	609	633	612	657
636	1110	639	682	642	702
667	1179	670	731	673	747
697	1248	700	779	703	792
727	1316	730	826	733	837
757	1385	760	872	763	881
787	1452	790	919	793	925
817	1519	820	965	823	969
848	1585	851	1012	854	1013
878	1650	881	1058	884	1057
908	1715	911	1104	914	1100
938	1779	941	1150	944	1144
968	1842	971	1194	974	1187
998	1905	1001	1238	1004	1229
1029	1966	1032	1281	1035	1270
1059	2027	1062	1324	1065	1311
1089	2087	1092	1368	1095	1352
1119	2147	1122	1411	1125	1392
1149	2209	1152	1454	1155	1432
1179	2268	1182	1496	1185	1471
1210	2327	1213	1538	1216	1510
1240	2386	1243	1580	1246	1550
1270	2443	1273	1621	1276	1588
1300	2500	1303	1660	1306	1627
1330	2556	1333	1699	1336	1665
1360	2611	1363	1738	1366	1701
1391	2665	1394	1776	1397	1736
1421	2719	1424	1813	1427	1771

Table B-4. Chempruf II Zipper/Material Interface vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 19 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
12	3	15	2	18	4
42	15	45	12	48	22
72	68	75	66	78	114
102	219	105	211	108	393
133	474	136	441	139	875
163	827	166	746	169	1525
193	1316	196	1137	199	2296
223	1987	226	1632	229	3121
253	2782	256	2246	259	3965
283	3622	286	2975	289	4820
314	4482	317	3775	320	5687
344	5356	347	4603	350	6566
374	6232	377	5449	380	7443
404	7109	407	6302	410	8316
434	7987	437	7158	440	9189
464	8860	467	8016	470	10063
495	9735	498	8877	501	10935
525	10612	528	9742	531	11807
555	11483	558	10606	561	12673
585	12354	588	11468	591	13540
615	13223	618	12330	621	14408
645	14087	648	13186	651	15267
676	14944	679	14039	682	16123
706	15804	709	14887	712	16977
736	16666	739	15737	742	17830
766	17523	769	16592	772	18687
796	18380	799	17448	802	19543
826	19236	829	18303	832	20395
857	20091	860	19153	863	21243
887	20951	890	20002	893	22094
917	21810	920	20856	923	22951
947	22669	950	21712	953	23805
977	23529	980	22563	983	24655
1007	24391	1010	23411	1013	25507
1038	25253	1041	24265	1044	26357
1068	26111	1071	25120	1074	27202
1098	26970	1101	25972	1104	28049
1128	27828	1131	26821	1134	28895
1158	28682	1161	27673	1164	29747
1188	29535	1191	28528	1194	30606
1219	30391	1222	29387	1225	31469
1249	31253	1252	30251	1255	32336
1279	32115	1282	31116	1285	33202
1309	32973	1312	31975	1315	34065
1339	33829	1342	32829	1345	34923
1369	34683	1372	33685	1375	35784
1400	35538	1403	34544	1406	36645
1430	36389	1433	35398	1436	37500

Appendix B

Table B-5. Chempruf II Outer Visor Material vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 18 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
2	1	5	1	8	2
32	11	35	11	38	15
63	18	66	18	69	26
93	24	96	25	99	35
123	32	126	32	129	45
153	299	156	75	159	65
183	969	186	292	189	493
213	1783	216	871	219	1329
244	2611	247	1697	250	2189
274	3448	277	2537	280	3052
304	4272	307	3364	310	3900
334	5086	337	4184	340	4736
364	5898	367	5003	370	5570
394	6711	397	5822	400	6412
425	7531	428	6640	431	7259
455	8355	458	7460	461	8107
485	9176	488	8271	491	8951
515	9993	518	9072	521	9790
545	10805	548	9863	551	10625
575	11616	578	10644	581	11460
606	12429	609	11413	612	12297
636	13249	639	12182	642	13143
666	14071	669	12928	672	13994
696	14888	699	13631	702	14841
726	15699	729	14301	732	15680
756	16499	759	14931	762	16510
787	17294	790	15521	793	17336
817	18089	820	16082	823	18161
847	18878	850	16606	853	18982
877	19660	880	17095	883	19795
907	20432	910	17563	913	20597
937	21196	940	18012	943	21399
968	21950	971	18431	974	22200
998	22663	1001	18828	1004	22980
1028	23326	1031	19218	1034	23730
1058	23967	1061	19592	1064	24446
1088	24587	1091	19951	1094	25132
1118	25177	1121	20292	1124	25798
1149	25734	1152	20619	1155	26434
1179	26266	1182	20939	1185	27032
1209	26780	1212	21246	1215	27599
1239	27271	1242	21542	1245	28137
1269	27738	1272	21828	1275	28652
1299	28184	1302	22111	1305	29148
1330	28611	1333	22386	1336	29626
1360	29024	1363	22656	1366	30093
1390	29422	1393	22918	1396	30543
1420	29804	1423	23174	1426	30980

Appendix B

Table B-6. Chempruf II Suit/Visor Interface vs. HD Liquid, 10 g/m²
Modified Static Diffusion Test, 18 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
11	2	14	2	17	2
41	9	44	9	47	9
72	15	75	15	78	14
102	21	105	21	108	20
132	27	135	26	138	25
162	37	165	34	168	31
192	118	195	76	198	59
222	351	225	178	228	127
253	710	256	323	259	225
283	1127	286	482	289	340
313	1562	316	655	319	469
343	2007	346	843	349	614
373	2471	376	1051	379	782
403	2971	406	1288	409	983
434	3525	437	1567	440	1228
464	4147	467	1896	470	1529
494	4849	497	2286	500	1900
524	5600	527	2756	530	2350
554	6372	557	3317	560	2891
584	7162	587	3968	590	3543
615	7969	618	4700	621	4289
645	8791	648	5473	651	5071
675	9623	678	6260	681	5866
705	10457	708	7059	711	6667
735	11287	738	7859	741	7470
765	12115	768	8667	771	8276
796	12946	799	9478	802	9087
826	13780	829	10295	832	9905
856	14618	859	11116	862	10727
886	15455	889	11939	892	11547
916	16291	919	12765	922	12374
946	17126	949	13591	952	13205
977	17959	980	14417	983	14036
1007	18801	1010	15247	1013	14875
1037	19650	1040	16082	1043	15713
1067	20499	1070	16916	1073	16546
1097	21348	1100	17751	1103	17380
1127	22198	1130	18588	1133	18215
1158	23046	1161	19422	1164	19049
1188	23890	1191	20254	1194	19877
1218	24734	1221	21087	1224	20707
1248	25582	1251	21922	1254	21547
1278	26431	1281	22749	1284	22383
1308	27284	1311	23580	1314	23215
1339	28146	1342	24429	1345	24057
1369	29012	1372	25286	1375	24913
1399	29870	1402	26132	1405	25761
1429	30722	1432	26970	1435	26600

Appendix B

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APPENDIX C
GB TABLES

Table C-1. Chempruf II Suit Material vs. GB Liquid, 10 g/m²

Modified Static Diffusion Test, 12 Mar 98

Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
2	0	5	0	8	0
32	25	35	246	38	57
62	137	65	612	68	209
92	301	95	828	98	379
122	433	125	994	128	513
152	537	155	1123	158	618
183	625	186	1234	189	707
213	704	216	1331	219	789
243	775	246	1416	249	864
273	840	276	1493	279	933
303	901	306	1566	309	996
333	957	336	1634	339	1055
364	1012	367	1698	370	1111
394	1063	397	1760	400	1164
424	1111	427	1817	430	1214
454	1157	457	1873	460	1261
484	1202	487	1925	490	1307
514	1245	517	1975	520	1350
545	1286	548	2024	551	1392
575	1325	578	2070	581	1432
605	1363	608	2114	611	1470
635	1400	638	2158	641	1508
665	1435	668	2201	671	1544
695	1469	698	2241	701	1579
726	1502	729	2281	732	1613
756	1536	759	2321	762	1646
786	1568	789	2358	792	1679
816	1599	819	2395	822	1711
846	1629	849	2430	852	1741
876	1657	879	2464	882	1770
907	1685	910	2497	913	1799
937	1712	940	2530	943	1827
967	1739	970	2561	973	1853
997	1765	1000	2591	1003	1879
1027	1790	1030	2621	1033	1904
1057	1815	1060	2650	1063	1929
1088	1839	1091	2679	1094	1952
1118	1862	1121	2706	1124	1976
1148	1886	1151	2732	1154	1998
1178	1908	1181	2758	1184	2020
1208	1930	1211	2784	1214	2041
1238	1951	1241	2810	1244	2062
1269	1972	1272	2834	1275	2082
1299	1993	1302	2858	1305	2102
1329	2013	1332	2881	1335	2122
1359	2032	1362	2905	1365	2141
1389	2051	1392	2927	1395	2159
1419	2070	1422	2949	1425	2177

Appendix C

Table C-2. Chempruf II Suit Seam vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 12 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
11	1	14	0	17	2
41	25	44	41	47	68
71	142	74	170	77	223
101	314	104	328	107	386
131	447	134	454	137	512
161	553	164	556	168	614
192	644	195	643	198	701
222	725	225	720	228	777
252	799	255	790	258	847
282	866	285	855	288	912
312	928	315	915	318	974
342	987	345	972	349	1032
373	1043	376	1027	379	1087
403	1097	406	1078	409	1138
433	1148	436	1127	439	1186
463	1196	466	1173	469	1233
493	1241	496	1217	499	1279
523	1284	526	1259	530	1322
554	1326	557	1299	560	1363
584	1367	587	1338	590	1403
614	1406	617	1376	620	1442
644	1443	647	1412	650	1479
674	1480	677	1435	680	1522
704	1515	707	1457	711	1564
735	1549	738	1490	741	1598
765	1583	768	1522	771	1630
795	1615	798	1552	801	1662
825	1646	828	1582	831	1693
855	1676	858	1611	861	1722
885	1705	888	1639	892	1751
916	1734	919	1666	922	1779
946	1761	949	1692	952	1806
976	1788	979	1718	982	1833
1006	1813	1009	1743	1012	1859
1036	1839	1039	1767	1042	1884
1066	1863	1069	1790	1073	1909
1097	1886	1100	1813	1103	1932
1127	1910	1130	1835	1133	1955
1157	1932	1160	1856	1163	1978
1187	1954	1190	1876	1193	1999
1217	1975	1220	1896	1223	2021
1247	1995	1250	1916	1254	2042
1278	2016	1281	1935	1284	2062
1308	2035	1311	1954	1314	2081
1338	2054	1341	1973	1344	2100
1368	2072	1371	1991	1374	2119
1398	2090	1401	2008	1404	2137
1428	2108	1431	2024	1435	2155

Appendix C

Table C-3. Chempruf II Glove Material vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 3 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	7	34	6	37	5
61	19	64	18	67	14
91	31	94	29	97	25
121	42	124	40	127	35
152	54	155	51	158	45
182	66	185	61	188	53
212	78	215	71	218	62
242	92	245	83	248	70
272	108	275	95	278	79
302	125	305	108	308	87
333	143	336	122	339	96
363	163	366	137	369	105
393	184	396	153	399	114
423	206	426	169	429	124
453	229	456	186	459	134
483	253	486	203	489	143
514	278	517	221	520	153
544	303	547	240	550	164
574	329	577	259	580	174
604	355	607	278	610	185
634	381	637	297	640	195
664	409	667	317	670	206
695	436	698	336	701	217
725	463	728	356	731	228
755	490	758	376	761	238
785	518	788	396	791	248
815	546	818	416	821	259
845	573	848	436	851	270
876	601	879	456	882	280
906	629	909	476	912	290
936	657	939	496	942	300
966	684	969	515	972	310
996	711	999	535	1002	320
1026	739	1029	555	1032	330
1057	766	1060	574	1063	339
1087	793	1090	593	1093	348
1117	819	1120	611	1123	357
1147	846	1150	630	1153	366
1177	872	1180	648	1183	375
1207	898	1210	666	1213	383
1238	923	1241	684	1244	392
1268	949	1271	701	1274	400
1298	974	1301	719	1304	408
1328	999	1331	736	1334	415
1358	1024	1361	753	1364	423
1388	1048	1391	770	1394	430
1419	1074	1422	787	1425	438

Appendix C

Table C-4. Chempruf II Zipper/Material Interface vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 3 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	2
40	8	43	6	46	11
70	26	73	18	76	22
100	73	103	33	106	34
130	178	134	60	137	55
161	361	164	108	167	92
191	644	194	189	197	154
221	1002	224	319	227	248
251	1392	254	517	257	380
281	1796	284	799	287	558
311	2206	315	1143	318	780
342	2619	345	1517	348	1043
372	3035	375	1909	378	1338
402	3455	405	2309	408	1658
432	3876	435	2712	438	1996
462	4294	465	3117	468	2348
492	4712	496	3525	499	2708
523	5129	526	3935	529	3072
553	5546	556	4344	559	3439
583	5962	586	4754	589	3808
613	6381	616	5168	619	4181
643	6800	646	5581	649	4552
673	7217	677	5995	680	4922
704	7633	707	6408	710	5291
734	8048	737	6822	740	5658
764	8461	767	7235	770	6024
794	8871	797	7646	800	6386
824	9279	827	8056	830	6744
854	9689	858	8466	861	7099
885	10098	888	8879	891	7451
915	10505	918	9292	921	7802
945	10910	948	9704	951	8149
975	11313	978	10114	981	8487
1005	11715	1008	10522	1011	8824
1035	12116	1039	10927	1042	9152
1066	12514	1069	11330	1072	9464
1096	12906	1099	11732	1102	9765
1126	13296	1129	12134	1132	10061
1156	13684	1159	12534	1162	10348
1186	14072	1189	12932	1192	10621
1216	14457	1220	13326	1223	10879
1247	14833	1250	13718	1253	11127
1277	15202	1280	14110	1283	11366
1307	15567	1310	14501	1313	11592
1337	15930	1340	14890	1343	11810
1367	16287	1370	15276	1373	12022
1397	16637	1401	15659	1404	12232
1428	16985	1431	16041	1434	12444

Appendix C

Table C-5. Chempruf II Outer Visor Material vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 10 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	3	0	6	0
30	21	34	35	36	31
60	92	63	117	66	111
90	189	93	213	96	203
120	279	123	305	126	288
150	362	153	387	156	367
180	440	183	464	186	441
210	515	213	537	216	512
240	584	243	605	246	577
270	649	273	669	276	638
300	711	303	731	306	695
330	769	333	788	336	750
360	825	363	842	366	803
390	879	393	895	396	854
420	931	423	946	426	903
450	981	453	996	456	951
480	1029	483	1044	486	998
510	1077	513	1092	516	1044
540	1123	543	1137	546	1087
570	1168	573	1182	576	1129
600	1211	603	1225	606	1170
630	1254	633	1266	636	1211
660	1295	663	1307	666	1250
691	1335	694	1347	697	1288
721	1375	724	1386	727	1326
751	1413	754	1423	757	1362
781	1451	784	1460	787	1398
811	1487	814	1496	817	1433
841	1523	844	1532	847	1467
872	1558	875	1568	878	1501
902	1593	905	1602	908	1533
932	1627	935	1635	938	1565
962	1661	965	1669	968	1597
992	1694	995	1701	998	1628
1022	1726	1025	1733	1028	1658
1053	1758	1056	1764	1059	1688
1083	1789	1086	1794	1089	1717
1113	1819	1116	1824	1119	1745
1143	1848	1146	1853	1149	1773
1173	1877	1176	1882	1179	1800
1203	1906	1206	1910	1209	1827
1234	1934	1237	1937	1240	1853
1264	1961	1267	1964	1270	1878
1294	1988	1297	1991	1300	1903
1324	2014	1327	2017	1330	1928
1354	2040	1357	2042	1360	1952
1384	2065	1387	2067	1390	1975
1415	2090	1418	2091	1421	1999

Table C-6. Chempruf II Suit/Visor Interface vs. GB Liquid, 10 g/m²
Modified Static Diffusion Test, 10 Mar 98
Cumulative Penetration (ng/cm²)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
9	0	12	0	15	0
39	35	42	16	45	42
69	117	72	78	75	132
99	211	102	170	105	222
129	298	132	256	135	304
159	378	162	334	165	381
189	452	192	407	195	453
219	523	222	476	225	521
249	588	252	540	255	584
279	649	282	600	285	643
309	706	312	657	315	700
339	761	342	711	345	753
369	814	372	762	375	805
399	865	402	812	405	854
429	915	432	861	435	902
459	964	462	907	465	948
489	1011	492	952	495	994
519	1056	522	996	525	1039
549	1100	552	1039	555	1081
579	1143	582	1080	585	1123
609	1185	612	1121	615	1163
639	1225	642	1160	645	1202
669	1265	672	1199	675	1240
700	1304	703	1236	706	1277
730	1342	733	1272	736	1314
760	1378	763	1308	766	1350
790	1414	793	1342	796	1384
820	1448	823	1377	826	1418
850	1483	853	1410	856	1452
881	1516	884	1443	887	1485
911	1549	914	1475	917	1517
941	1581	944	1506	947	1548
971	1613	974	1537	977	1578
1001	1643	1004	1567	1007	1608
1031	1673	1034	1597	1037	1637
1062	1703	1065	1626	1068	1666
1092	1732	1095	1654	1098	1693
1122	1761	1125	1681	1128	1721
1152	1789	1155	1708	1158	1748
1182	1816	1185	1735	1188	1774
1212	1843	1215	1761	1218	1800
1243	1869	1246	1786	1249	1825
1273	1895	1276	1811	1279	1850
1303	1920	1306	1836	1309	1875
1333	1944	1336	1860	1339	1899
1363	1968	1366	1883	1369	1922
1393	1991	1396	1906	1399	1945
1424	2014	1427	1929	1430	1968

Appendix C